AMENDED CLAIMS

[Received by the International Bureau on 31 August 2004 (31.08.2004): original claims 1-44 replaced by amended claims 1-34 (6 pages)]

1. A bumper system for a vehicle, comprising:

a reinforcement beam adapted for attachment to a vehicle frame; and

a thermoformed energy absorber supported on a face of the reinforcement beam, the energy absorber being formed from a single sheet of material by a thermoforming process to have a base flange and a plurality of thermoformed longitudinally-elongated crush boxes that extend generally perpendicularly from the base flange in a fore/aft direction parallel a direction of expected impact; the crush boxes each having opposing side walls and orthogonally-related end walls and a side-wall-supported front wall with the crush boxes each being spaced apart from each other along the base flange; the crush boxes each defining a separate rearwardly-facing opening and the side walls, end walls, and front walls being continuous and not having any apertures formed therein;

the energy absorber defining a forward-facing surface and a rearward-facing surface, each being open and unobstructed in a linear direction parallel the fore/aft direction and not having undercut surfaces, whereby the energy absorber can be thermoformed from the sheet of material by passing a portion of mold tooling in a forming direction parallel the fore/aft direction through the base flange linearly into the rearwardly-facing openings defined by the crush boxes; the opposing side walls being stretched during the thermoforming process and having a thickness dimension less than a thickness of the front walls and of the base flange due to the thermoforming process.

2. The bumper system defined in claim 1, wherein the reinforcement beam has a first face surface defining a relatively-flat first shape and wherein the front walls define a second face surface having a relatively non-flat second shape different than the first shape, the second shape being adapted to engage and support a fascia.

3. The bumper system defined in claim 1, wherein the crush boxes have at least one laterally-defined concavity in one of the side walls such that the crush boxes, in front view, define one of an "H" shape, a "T" shape, an "X" shape, and a "C" shape.

4. The bumper system defined in claim 3, wherein at least one of the side walls has a wavy shape with undulations that extend parallel the fore/aft direction.

5. The bumper system defined in claim 3, wherein the crush boxes are spaced longitudinal and each extends vertically at least half of a total vertical dimension of the energy absorber.

6. The bumper system defined in claim 2, wherein, starting at a center of the energy absorber, inboard ones of the crush boxes have a different height dimension in the fore-aft direction than outboard ones of the crush boxes.

7. The bumper system defined in claim 1, wherein the opposing side walls define planes that extend generally parallel the fore-aft direction.

8. The bumper system defined in claim 1, wherein at least one side wall includes a front portion defining a first plane, a second portion defining a second plane parallel the first plane, and an offset connecting portion that, when the bumper system is impacted, cases the first and second portions to telescope overlappingly onto each other.

9. The bumper system defined in claim 1, including a second sheet of material bonded to the single sheet of material and forming air-filled air-cushioning pockets within the crush boxes.

10. The bumper system defined in claim 9, wherein the second sheet of material includes vents for controlling flow of air exiting the air-cushioning pockets.

11. The bumper system defined in claim 1, wherein the face of the reinforcement beam includes one of a depression feature and a protrusion feature, and the base flange includes the other of the depression feature and protrusion feature, and wherein the one feature engages the other feature to retain the energy absorber on the face of the reinforcement beam upon an impact against the bumper system.

12. The bumper system defined in claim 11, wherein the depression feature is a channel, and the protrusion feature is a ridge.

13. The bumper system defined in claim 1, including a thermoformed second energy absorber with second crush boxes formed therein that mate against the first-mentioned crush boxes.

14. The bumper system defined in claim 1, wherein the crush boxes have a transverse cross section with a maximum height dimension of about 35 mm.

15. The bumper system defined in claim 14, wherein at least some crush boxes have a height dimension is a maximum of about 25 mm.

16. The bumper system defined in claim 1, wherein the side walls have thicknesses of less than about 2.0 mm.

17. The bumper system defined in claim 1, wherein the thermoformed energy absorber includes a material having a memory and that will recover to a near-original shape after being crushed.

18. The bumper system defined in claim 1, wherein the base flange includes flexible sections located between the crush boxes, such that the energy absorber is bendable and is adapted to flexibly deform to engage a face of a curvilinearly swept beam.

19. The bumper system defined in claim 1, including a second energy absorber positioned on and engaging the face of the beam and having a front surface engaging and supporting the thermoformed energy absorber.

20. A bumper system comprising:

a beam; and

a thermoformed energy absorber having a base flange and thermoformed crush boxes formed therein, the crush boxes being spaced apart and each having side walls, end walls and a face wall to form a box shape, at least one of the side walls including a front portion defining a first plane, a second portion defining a second plane parallel the first plane, and an offset connecting portion that, when the bumper system is impacted, cause the first and second portions to telescope overlapping onto each other in a predictable manner.

21. The bumper system defined in claim 20, including a second sheet bonded to the thermoformed energy absorber, the second sheet having portions forming air-filled air-cushioning pockets under the crush boxes.

22. A bumper system comprising:

a bumper beam having a face and at least one elongated recess formed in the face; and

a thermoformed energy absorber having a base flange and crush boxes formed in the energy absorber in a direction perpendicular to the base flange and further having at least one thermoformed ridge extending from the base flange into engagement with the recess to retain the energy absorber on the face during a vehicle crash.

23. The bumper system defined in claim 22, wherein the recess comprises a longitudinally-extending channel formed in a face of the beam.

24. A bumper system comprising:

a metal tubular bumper beam having a face;

a first polymeric energy absorber having energy-absorbing blocks selected from one or both of hollow crush boxes and foam blocks; and

a thermoformed second polymeric energy absorber covering a substantial portion of a front of the first polymeric energy absorber, the second polymeric energy absorber including a base flange engaging the first polymeric energy absorber and including at least one crush box formed therein.

25. The bumper system defined in claim 24, wherein the first and second polymeric energy absorbers include mating surfaces that frictionally and detentingly engage to retain the energy absorbers together.

26. A vehicle bumper system comprising:

a reinforcement beam having a face and being adapted for attachment to a vehicle frame;

an energy absorber abutting the face including a thermoformed component; and

a fascia covering the beam and the energy absorber;

the thermoformed component having a base sheet adjacent the face and a plurality of crush boxes extending forwardly from the base sheet into engagement with the fascia; the crush boxes each having opposing side walls and a front wall that define orthogonally-related planes, and also having top and bottom walls that are undulating in a longitudinal direction with alternating convex and concave regions; the crush boxes being open on at least one side to facilitate thermoforming the thermoformed component, the crush boxes defining shapes selected from a group of shapes where at least one of the side walls defines a concavity.

27. The bumper system defined in claim 26, wherein the at least one side wall has a shape consisting of one of the following shapes: I, H, C, T, and X.

28. The vehicle bumper system defined in claim 27, wherein the side walls of the crush boxes include at least two different ones of the shapes I, H, C, T, and X.

29. The vehicle bumper system defined in claim 26, wherein at least one of the crush boxes is elongated to at least two times its width.

30. The vehicle bumper system defined in claim 26, wherein the thermoformed component further has a rearwardly-extending feature formed into the base sheet that extends into one channel formed in the face of the beam for assisting in retaining the energy absorber on the face during a vehicle crash.

31. The vehicle bumper system defined in claim 26, wherein at least half of the crush boxes are less than about 35 mm high.

32. The vehicle bumper system defined in claim 31, wherein the crush boxes vary in height.

33. The vehicle bumper system defined in claim 26, wherein the base flange is flexible and bendable, such that the thermoformed component is bendable to engage the face of the beam despite a difference in shape when in an unstressed unattached state.

34. The vehicle bumper system defined in claim 26, wherein at least one of the walls of the crush box includes an offset that, upon receiving an impact causing the bumper system to move through a stroke, overlappingly wraps back onto itself during the stroke.